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ABSTRACT

This paper reports on the dilution effect of the ozone layer which jeopardizes a section of land in Chile from 53 degrees South latitude to 33 degrees South and the necessity of preparing the population for the possible ecological consequences of an increase in ultraviolet radiation. Scientists in Chile assume part of this task by studying the short and long term effects upon different ecosystems. Education also plays a role in that the problem requires an attitude change in the population. A discussion is provided of the task presented to science educators by the ozone problem, including insight into the role that student motivation plays in science learning. A proposal is made which recommends that instruction not start from the basic content and include at a later time a discussion of applications, but start with a real problem and from there motivate the students to seek explanations in the concepts, laws, scientific processes, and procedures. The experiences described in this paper are based on a three-year pilot program in physics. (DDR)

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Context Related Curriculum Planning for Science Teaching: Proposal to Teach Science around the Ozone Problem

by
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CONTEXT RELATED CURRICULUM PLANNING FOR SCIENCE TEACHING: A PROPOSAL TO TEACH SCIENCE AROUND THE OZONE PROBLEM

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INTRODUCTION

Since Chile is a narrow and long country, where the so called dilution effect of the ozone layer jeopardizes most of the land from Punta Arenas (53 degrees South) to La Serena (33 degrees South), it is necessary to prepare its population for possible ecological consequences of UV-B radiation increase.

Scientists in Chile assume part of this task by studying short and long term effects upon the different ecosystems. Education also plays a role since the problem requires an attitude change in population.

THE OZONE/UV-RADIATION PROBLEM - general information

In over 20 years of reports from several sources, indications are that the ozone concentration is gradually and permanently decreasing each spring over Antarctica. The so called OZONE HOLE is increasing in size. But since ozone is the only element which effectively absorbs solar UV radiation, the observed depletion of the ozone layer might negatively affect life in that region.

Punta Arenas, located at the edge of the antarctic ozone hole, is the southernmost major city in the world (53,3 degrees South). Production activity in Punta Arenas is related to wheat crops, forestry, fishery cattle, and especially sheep. The increasing damage in the ozone layer over the region could, therefore, cause larger exposure to UV-radiation, and reduce food production both in the South of Chile and Argentina.

Research results with several atmospheric models suggest that the ozone layer depletion is the effect of many trace gases from human activity, such as CFCs (chlorofluorocarbons), CH_4, N_2O and CO_2. Worrysome questions are posed with respect to the biological consequences of the combined seasonal and year round ozone depletion above Punta Arenas. Scientists are looking for an answer to these questions, such as how to reduce the problem and how big are the consequences upon the health of living organism; how does the depletion affect the photosyntesis process, how do living organism respond and which are their adaptative mechanisms for short and long term UV-B radiation exposure events, among others.

There are also some educational questions which we, as science educators, could and should answer.

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THE TASK FOR SCIENCE EDUCATORS

In Chile, science teaching has as main goals to contribute to a better quality of life, to allow the students to give a positive direction to their life, and to allow them to turn into constructive members of society who know themselves and their environment.

Closely related to these objectives is the ozone-UV radiation problem, therefore science teaching should consider this content and curriculum developers should accordingly organize the science contents to be included for each school year.

The rapidly thinning ozone layer has created widespread concern among people living in this region. Since then several surveys have been conducted because Punta Arenas, due to its unique position within the ozone hole, is a living prototype model, probably ten years ahead of the rest of the world, regarding photobiological change.

The Ozono Group in the Universidad de Magallanes (UMAG) is presently undertaking a range of studies related to the Antarctic ozone hole and ground level UV radiation. Studies by the UMAG ozone group have already shown an increase in ground levels of UV radiation by as much as 400% during the time that the ozone hole lies above southern Chile. The group has established an effective system to coordinate the dissemination of the information they receive to the public.

A number of satellite systems are presently able to collect data on high altitude ozone concentrations and to transmit this to receiver stations located in different places around the world.

The UMSG ozone group has been studying the movement of the antarctic ozone hole for the past decade. Estimates from UV-B radiation measurement show that in 1992 approximately a doubling of the average daily exposure was experienced in Punta Arenas on those individual days on which the ozone depletion was greatest in September and October.

Even though a decrease in stratospheric ozone does not necessarily translate into an increase in the dangerous short-wave UV-B, large increases in ground level UV-B (100% above normal) have been measured in the recent years in the south of Chile and Argentina, which have shown good correlations with the measured decrease in the ozone column.

UV-light passing through the ozone hole could alter the balance of the species that make up the different levels of the ecosystem. Several studies have been conducted in an attempt to measure the damage done by the extra UV-B radiation coming through the ozone hole. A net of sixteen stations has been installed in different cities from Chile and Argentina. These stations have been provided with two types of sensors for solar UV radiation. This has allowed to further investigate the phenomena and analyze how living organisms respond and to analize their adaptative mechanisms for short and long term exposure events.

The answer to the increase in UV-B radiation has been studied in wheat crops. Sea plankton has also been studied. A survey has been conducted to evaluate the consequences of a short term increase in UV-B radiation upon the ocean water. The effect of UV radiation on animals and human beings has also been studied. Studies have found no acute or inmediate impacts on human health, the samples being too small to allow long term predictions. Data show no convincing evidence of acute eye disease associated with the ozone hole. Findings related to eye disease rates among shepherds and fishermen, who spend most of the time outdoors, and among hospital workers, are uncertain. Although sheep from several ranches showed higher rates of eye infections, researchers state that ophthalmic findings could not be related to the ozone problem.

The above information shows that although direct stratospheric measurements of the ozone layer are being registered, no concerted efforts exist to relate such measures to actual health effects. Nevertheless, human inmunology, skin cancer, cataract and the effects of UV radiation in the antarctic region have been identified as priority research areas for populations exposed to ozone depletion conditions.

Several multidisciplinary teams have been formed and have designed pilot studies, such as above described, to identify possible health effects associated with the ozone hole over southern Chile.

There is no doubt that a major and more accurate information is needed to successfully confront not only the potentially dramatic antarctic ozone hole created by our civilization, but also the unexpected problems which the always increasingly development is possible reserving for the future world population.

Science educators are aware of these and ather related issues which affect society. Since some years sceince education is not only seen as that curriculum component which provides the students with scientific knowledge and prepares them for future scientific studies, but also as an important component of their personal development. *Science for All* is the idea. Science for the citizen, science for daily life, science for the job, science for the scientist.

One of the problems which science educators must face is the students' lack of interest in science. From the application of an interest questionnaire developed at the Institute for Science Education (IPN), in Kiel, Germany, and translated to spanish at the University of Concepcion, it has been possible to gather information. The questionnaire was applied to a sample of about 2000 students from grades 5th to 12th in Concepcion. Results indicate that not many students show high or very high interest in the different topics of physics. While by grade 5th around 60 percent of students show interest, by grade 12th, less than 50 percent are interested. A significant decrease apperars along the school years.

However, this study has also shown that some topics attract the students better than others. The contexts with which arise more interest in students is are those related to health, environment and society issues.

Chilean educational authorities have shown their worry about the lack of interest of students in science related professions, which in some way has to do with what we have just stated. The 1995

admission process to universities showed many careers in the science and technology area (engineering, science teachers among others) where vacancies offered were not completed.Compared to the situation in 1984 the above is worrysome: in that time applications were close to double the number of vacacncies offered. Critical is the case of Mathematics and Physics Teachers Training and Bachellors in Physics, where for each 10 vacancies there are only 4 to 8 applicants.

Trying to revert the situation , modern approaches to science teaching have identified five contexts as those under which science should be taught as suitable for someone living in our society as it is and as it will be tomorrow. "This 'someone' es everyone, male or female, beginning with the youth who has finished his schooling and is looking for an apprenticeship, and including the retiree who goes for walks in the park and whose favorite pastime is playing pinochle with his old friends" (Haussler et al, 1988, p.2).

The suitable science education for this 'someone' means not only passing on scientific knowledge but also understanding scientific and technological developments and their consequences, recognising dangers arising from scientific and technological developments, avoiding sources of danger and accidents in daily life, knowledge of technical systems, appliances, etc. found in the home or used in maintaining a household, using positively the leisure time, integrating positively the social and public spheres, acquiring an understanding of the work world and the basic qualifications for employment. It also means personal emotional development, subjective satisfaction from learning about the natural sciences, personal intellectual development and enlightment.

Corresponding to this view of science education, several topics could be found as suitable curriculum content for science courses.

Chilean school science program, although differently structured, biology, chemistry and physics school programs allow flexibility in choosing how to organize the content. For the proposal made here we will assume the physics curriculum structure. It consists on basic contents and optional modules where different applications are analysed. The proposal we make recommends not to start from the basic contents and discuss later (if possible) some applications, but to start from a **real problem** (a so-callled application problem) and from there on to motivate the students to seek for explanations in the structures (concepts, laws, scientific processes or procedures, etc.)

This approach has proved successful in physics. It has been applied during 3 years by some teachers who collaborate with us at the University of Concepcion. They report that pupils show more interest than when working in a more traditional way. Achievement tests also show a satisfactory level of learning. Information gathered through an opinion questionnaire applied to pupils indicates that they liked this approach which might also be used in biology and chemistry. Below is described the science chilean curriculum for secondary school (grade 8th to 12th):

	Physics
Grade 9th:	Energy transfer 1; Waves 1 (wave concept); Interactions 1 (force and pressure)
Grade 10th:	Energy transfer 2 (heat and temperature); Waves 2 (bidimensional waves); Interactions 2 (collisions, momentum)
Grade 11th:	Energy transfer 3 (mechanic energy, heat and work); Waves 3 (light); Interactions 3 (Newton laws)
Grade 12th:	Electric energy; Atomic and Nuclear physics
	Biology:
Grade 9th:	Health education; basis for biological balance in nature
Grade 10th:	Unity and diversity in the living world; Energy and matter exchange between organisms and their environment
Grade 11th:	Organic integration systems
Grade 12th:	Reproduction and development of living beings; Inherited characteristics transmission
	Chemistry:
Grade 9th:	Chemistry and nature (water, air, soil, energy)
Grade 10th:	Nuclear chemistry and nature (natural resources, food, health, chemical industry)
Grade 11th:	Chemistry, a science; Chemical reactions
Grade 12th:	Organic chemistry; Redox reactions.

Our proposal has the following main objectives:

A. To enable the person:

*to perceive and to make judgements on the intimate connections between scientific and technological developments, in the one hand, and economic and political developments, on the other;
* to integrate scientific and technological developments with the science knowldge he/she already has;
*to understand and to pass judgement on misdevelopments and their consequences for the environment;
*to act with full awareness of his/her social responsability and to reflect critically on what he/she is doing;
*to discuss current problems and to translate one's own insights into socio-political action.

B: To make it easier for the person to meet the demands made in daily life, with knowledge and understanding of the ways in which technical objects function, in which one must deal with them so as to recognise sources of danger and to avoid accidents.

C. To enhance and guide the attitudes and feelings with which a human being confronts nature and technology and in this way furthers personal emotional development and to lead to the person's voluntary engagement with science for its own sake and in a subjectively satisfying way.

D: To pass on important parts of scientific knowledge, developing cognitive abilities as well as scientific methods of thought and conceptual schemas, providing also an accurate picture of the world and of the laws which govern it thus contributing to the individual awareness and understanding of both the natural and the technological environment.

E: To impart the basic qualifications for many occupations and to give a glimpse into the technical workworld and the occupations which are shaped by the science.

The ozone problem is a **real** problem in Chile and provides a good opportunity to seek for explanations in the contents of chemistry, biology and physcis.

The content of physics, chemistry and biology is organised around the ozone hole problem. Physics, chemistry and biology basic contents give explanations to different aspects of the ozone problem.

The Proposal
Thema: The ozone hole, a menace to the quality of life

9th grade

1. The sun, our main source of energy

1.1 The light of the sun allows the life in earth: photosynthetic activity and atmospheric CO_2-O_2 balance
1.2 The light of the sun is a wave
1.3 Waves transport energy
1.4 Energy is necessary for human activity
1.5 Different sources of energy
1.6 Waves elements: speed, frequency, wavelength, amplitude
1.7 Sun light consists on different wavelengths
1.8 UV radiation is part of the sun light
1.9 The effect of waves depends upon their wavelength

2. Air is important for living beings

2.1 Air is composed by different elements
2.2 Ozone is a component of the atmosphere
2.3 Ozone protects the quality of life in earth
2.4 Ozone uses energy from UV radiation and absorbs it
2.5 Air is polluted by human activity
2.6 Some air pollutants destroy the ozone layer

3. Food is necessary for our health

3.1 Nature provides food for all living beings
3.2 Living beings interact among others and with the environment
3.3 Soil, water and air contribute to ecological balance
3.4 Fresh food is important for our health
3.5 The sun makes life possible but heat damages fresh food
3.6 Cold allows to preserve food
3.7 Industry contributes to preserve food
3.8 Industry uses different processes to preserve food
3.9 Food is preserved in freezers
3.10 Freezers design includes the use of some products which can damage the ozone
3.11 Science and technology seek substitute products for freezers design which do not damage the ozone

10th grade

1. Food is important for mankind

1.1 Chemical industry contributes to food production
1.2 Food provides energy
1.3 The sun provides heat energy
1.4 Heat transfer is important for the atmospheric behavior
1.5 Atmospheric pollution is affected by atmospheric termodynamic processes
1.6 Ozone concentration in the atmosphere is affected by climatic conditions
1.7 Ozone filters UV radiation coming from the sun
1.8 Much of our food comes from the ocean water
1.9 UV radiation penetrates the water
1.10 UV radiation alters life in water systems

2. The UV radiation and the electromagnetic spectrum

2.1 Waves are reflected, refracted, diffracted and absorbed
2.2 Electromagnetic waves - the electromagnetic spectrum
2.3 Electromagnetic waves travel in space
2.4 The atmosphere reflects, refracts, diffracts and absorbs electromagnetic waves
2.5 UV radiation is absorbed by the ozone
2.6 The ozone protects from UV radiation

3. The cell as basic structure and origin of living beings

3.1 The cell structure
3.2 Chemical components of the cell
3.3 UV radiation affects the cells
3.4 Diversity of living beings - phytoplankton and zooplankton
3.5 UV radiation affects the different ecosystems
3.6 Living beings adapt to changes in the environment
3.7 Man activity changes the environment
3.8 Man is responsible for preserving the environment

11th grade

1. Optical systems help man

1.1 The microscope helps to study the cell
1.2 Optical systems in the microscope
1.3 Optical systems help to study the space
1.4 Our eye, an optical system
1.5 The eye suffers with UV radiation
1.6 UV radiation intensity depends upon atmospheric conditions
1.7 UV radiation changes together with ozone concentration in the atmosphere

2. Energy is necessary for chemical change

2.1 Matter is made out of atoms
2.2 Atoms have electric components
2.3 Atoms emit waves
2.4 Emission spectrum
2.5 The study of light through its spectrum
2.6 Energy participates in all chemical change
2.7 UV radiation transports energy
2.8 UV radiation provides energy for atmospheric reactions (O_2 and O_3)

3. The eye, as main information receptor for man and animals
3.1 The eye structure
3.2 Vision and eye health
3.3 UV-B radiation damages the eye
3.4 How to protect the eye from UV-B radiation

12th grade

1. Carbone, an important element
1.1 Carbone in chemical industry
1.2 CFCs are made out of carbone
1.3 CFCs are used in cold food preservation industry
1.4 CFCs are used to isolate and save energy
1.5 Cosmetic industry uses CFCs
1.6 CFCs emission to the atmosphere
1.7 CFCs reactions with the ozone
1.8 CFCs destroy the ozone layer

2. Heredity and ADN
2.1 ADN structure
2.2 Genetic code
2.3 Mutations and ADN
2.4 UV radiation damages the ADN
2.5 Skin health and UV radiation
2.6 Cosmetic industry helps to protect the skin
2.7 UV radiation in medicine

Some Comments around the Proposal

It is important that Physics, Biology and Chemistry teachers integrate among themselves. Students should see that each science has a role to play with respect to the ozone-UV-B radiation problem. Thus learning will turn meaningful. They will make different connections between the concepts studied in each course and the ozone problem will turn into a good organizer of knowledge.

The teacher should emphasize the context which relates better to the actual school, students or local environment conditions.

With respect to the ozone/UV-B radiation problem, reports indicate that Chile does not contribute significantly to atmospheric pollution through CFCs emmission:

Country	USA	E.C.	Japan	Soviet Union	Canada	Chile
Global emmission	35%	34%	14.2%	13.3%	2.5%	0.9%

Considering this, students should recognize the ozone problem as a serious one which, although not caused by Chile, affects the land and the population health and quality of life. They should understand the physical and chemical concepts related to the ozone decrease in the atmosphere,

those related to the characteristics of UV radiation; they should also understand the biological aspects of damage caused by UV radiation to living beings.

Students should be also made conscious of the effort done by national industries for reducing emmission and use of CFCs although knowing that their impact upon the global atmospheric pollution is very small. Thus they will recognise how scientific development and technological progress must collaborate to maintain the quality of life. Perhaps the above knowledge will attract them to science and to the choice of science as a professional alternative.

The curriculum, although taking into account the understanding of technological progress, should place more emphasis on the knowledge of sources of danger and of ways for health protection. Curriculum in other countries should place the emphasis on global atmospheric damage and on the need of attitudinal changes, integrating social and public spheres, and understanding of scientific and technological development and their consequences.

The proposal we have presented here is based upon the science school curriculum in Chile, but could be used as a model to consider the ozone/UV-B radiation problematic in school science courses.

Besides this, students should recognize the ozone problem as a serious one which, although not caused by Chile, affects the land and the population health and quality of life. They should understand the physical and chemical concepts related to the ozone decrease in the atmosphere, those related to the characteristics of UV radiation; they should also understand the biological aspects of damage caused by UV radiation to living beings.

Students should be also made conscious of the effort done by national industries for reducing emmission and use of CFCs although knowing that their impact upon the global atmospheric pollution is very small. Thus they will recognise how scientific development and technological progress must collaborate to maintain the quality of life. Perhaps the above knowledge will attract them to science and to the choice of science as a professional alternative.

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